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IN THE INTERNATIONAL BUREAU OF WORLD INTELLECTUAL PROPERTY ORGANIZATION/PCT EXAMINATION OFFICE

In re International Application: Barry W. TOWNSEND, et al.

International Application No.: PCT/US03/09506

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Title: PROSTHETIC FOOT WITH TUNABLE PERFORMANCE AND IMPROVED VERTICAL LOAD/SHOCK ABSORPTION

AMENDMENT UNDER PCT ARTICLE 34

Replacement pages 26, 29, 30, 31, 33, 35, 36 and 37 are enclosed with amendments to the specification, claims and abstract. Three sheets of replacement drawings containing amended drawing Figs. 28-34 are also enclosed.

The amendments to the drawings are to add and correct reference numerals used therein to conform the drawings with the specification as amended. In particular:

in Fig. 28 the reference numerals 70 have been changed to 77 and 78, respectively, and the reference numeral 76 and a lead line and a bracket therewith have been added;

in Fig. 29, the reference numeral 70 and lead line therefrom have been added in the correct location, original reference numeral 70 has been changed to 78, and the reference numeral 75 and an arrow therefrom have been added;

in Fig. 30 there is no change;

in Fig. 31 the reference numerals 70 have been changed to 77 and 78, respectively, the reference numeral 75 and an arrow therefrom have been added, and reference numerals 70, 71 and 72 and lead lines therefrom have been added,

and reference numeral 76 and a lead line and a bracket therewith have been added.

- in Fig. 32 the reference numerals 70 have been changed to 77 and 78, respectively, the reference numeral 72 and a lead line therefrom have been added, and the reference numeral 76 and a lead line and a bracket therewith have been added;

- in Fig. 33 reference numerals have been changed, namely 75 to 85, 76 to 86, 77 to 87 and 78 to 88;

- in Fig. 34 reference numerals have been changed, namely 75 to 85, 76 to 86 and 78 to 88.

The specification replacement pages 26, 29, 30 and 37 contain the following changes:

page 26, the expression "spring" in original line 12 has been changed to --coiled spring--;

page 29, in original lines 18-21, the references to reference numerals 75, 76 and 77 have been changed to 85, 86 and 87, respectively;

page 30, in original line 1, the references to reference numerals 76 and 77 have been changed to 86 and 87, respectively;

page 37, the Abstract has been amended to include reference numerals 64, 65, 66, 67, 68, 69, 73, 74 and 75 within parentheses in reference to the embodiment in Figs. 28-32 as amended, and the expression "spring" in the penultimate line of the single paragraph of the Abstract has been changed to --coiled spring-- to be more specific concerning the form of the spring 69 in the embodiment as originally disclosed, see lines 1 and 2 on page 27 of the specification and Fig. 29 of the drawings, for example.

The changes in the claims on replacement pages 31, 33, 35 and 36 are:

Page 31 -

Claim 1 - in line 5, "spring" has been changed to --coiled spring--; and

Claim 2 - in line 2, "spring" has been changed to --coiled spring--.

Page 33 -

Claim 14 - in line 5, "spring" has been changed to --coiled spring--.

Page 35 -

Claim 20 - in line 2, "spring" has been changed to --coiled spring--.

Page 36 -

Claim 25 - in each of lines 5 and 6 "coil spring" has been changed to --coiled spring--, in line 9, "the midportion" has been changed to --the arch shaped midportion and the compressed coiled spring of the midportion--.

The changes in the claims clearly distinguish the present invention over the patents to Phillips 5,514,185 and Chen 5,507,838 cited in the International Search Report. Neither reference discloses a foot keel, prosthetic foot or method of absorbing and retaining vertical load in a prosthetic foot during varied activities as in the present invention wherein a coiled spring of an arch shaped midportion of a foot keel is provided to improve dynamic response capabilities as discussed in the application specification. In example embodiments of Figs. 28-34, the posterior end of the arch shaped midportion of the foot keel is coiled downwardly and anteriorly to form the coiled spring 69. These features are not disclosed or suggested by the references.

A Demand for international preliminary examination under Chapter II is being filed concurrently with this Amendment.

Respectfully submitted,

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Enclosures: Replacement pages 26, 29, 30, 31, 33, 35, 36 and 37
Replacement drawing sheets 10/12, 11/12 and 12/12 containing amended Figs. 28-34.

receiving a pylon 15. Once received in the opening, the pylon can be securely clamped to the calf shank by tightening bolts 60 and 61 to draw the free side edges 62 and 63 of the calf shank along the opening together. This pylon connection can be readily adjusted by loosening the bolts, telescoping the pylon relative to the calf shank to the desired position and reclamping the pylon in the adjusted position by tightening the bolts.

A prosthetic foot 64 of a further embodiment of the invention is shown in Figures 28-32. The prosthetic foot 64 includes resilient longitudinally extending foot keel 65 that has posterior and anterior plantar surface weight bearing areas 66 and 67, respectively, and non-weight bearing arch shaped midportion 68 extending between the weight bearing areas. To enhance the ability of the high performance prosthetic foot to absorb and return vertical load or vertical impact forces, the midportion is formed with a coiled spring 69 which is compressed to absorb and expanded to return vertical load during use of the prosthetic foot. This elastic loading of the spring 69 is in addition to the elastic loading of the arch shaped length of the midportion which occurs by expansion as explained in connection with the previously described embodiments. Upon lowering the vertically directed forces on the prosthetic foot, the energy stored by the midportion arch shaped length and the compression spring 69 of the midportion is released

These features enhance the ability of the prosthetic foot to maintain full function without breakage under vertical forces during varied activities wherein the vertical forces may range from minimal vertical force being applied (three times body weight) to wherein maximum vertical force (13 times body weight) is applied. In the embodiment

enables changing the direction of the dynamic response of the prosthetic foot. As in the previous embodiments, the upper portion of the calf shank 73 forms the lower, prosthetic part of a leg. This upper portion also extends upward in a substantially curvilinear manner so as to expandable and compressible in response to ground reaction forces thereon during gait for storing and releasing energy to improve dynamic response of the prosthetic foot in gait. The prosthetic foot 64 may have rubber or foam pads, not shown, on the lower forefoot and hindfoot portions of the foot keel as cushions. Also, as in the other embodiments, a cosmetic covering, not shown, is provided over the prosthetic foot as will be readily understood by the skilled artisan.

A wedge 79 formed of plastic or rubber, for example, is adhesively bonded to the foot keel at the anterior juncture of the foot keel and the lower end of the calf shank as shown in Fig. 29. The wedge serves as a stop to limit dorsiflexion of the upwardly extending calf shank in gait. The size of the wedge can be selected, wider or narrower in the plane containing the longitudinal axis of the foot, to permit adjustment of the desired amount of dorsiflexion. Of course, in the first instance the resilience of the calf shank is selected for optimal dynamic functioning of the calf shank and foot.

The embodiment of the invention depicted in Figures 33 and 34 is a prosthetic foot 85 similar to that in Figures 28-32 except that the prosthetic foot is provided with an attachment fitting 86 mounted on a dorsal surface of the posterior end of the arch shaped midportion 87 for connecting the foot keel of the foot directly to a supporting structure attached to a leg stump of a person. In the example embodiment, fitting 86 is in the form of an inverted pyramid-shaped attachment fitting connected to an

attachment plate 88 attached to the upper surface of the midportion 87 near the posterior end thereof. The pyramid fitting is received by a complimentarily shaped socket-type fitting on the depending prosthetic socket for joining the prosthetic foot and prosthetic socket.

The prosthetic foot 64 and calf shank can be fabricated from a variety of resilient materials. These materials may include, but are not limited to, plastics, polymer impregnated and encapsulated laminates (carbon fibers, fiberglass, Kevlar impregnated with epoxy thermosetting resins), and alloys such as spring steel, aluminum, titanium, or other flexible metals such as Flexon (trade name for flexible titanium).

This concludes the description of the example embodiments. Although the present invention has been described with reference to a number of illustrative embodiments, it should be understood that numerous other modifications and embodiments can be devised by those skilled in the art that will fall within the spirit and scope of the principles of this invention. More particularly, reasonable variations and modifications are possible in the component parts and/or arrangements of the subject combination arrangement within the scope of the foregoing disclosure, the drawings, and the appended claims without departing from the spirit of the invention. In addition to variations and modifications in the component parts and/or arrangements, alternative uses will also be apparent to those skilled in the art.

CLAIMS

What is claimed is:

1. A longitudinally extending foot keel for a prosthetic foot, the foot keel comprising:

posterior and anterior plantar surface weight bearing areas and a non-weight bearing arch shaped midportion extending between the weight bearing areas,

wherein the midportion is formed with a coiled spring which is compressed to absorb and expanded to return vertical load during use of the foot keel in a prosthetic foot.

2. The foot keel according to claim 1, wherein the posterior end of the arch shaped midportion is a coiled downwardly and anteriorly to form the coiled spring.

3. The foot keel according to claim 1, wherein the posterior plantar surface weight bearing area of the foot keel is connected to the arch shaped midportion by way of the spring.

4. The foot keel according to claim 1, wherein the arch shaped midportion extends continuously to the anterior plantar surface weight bearing area of the foot keel.

5. The foot keel according to claim 1, further comprising an attachment fitting mounted on a dorsal surface of the posterior end of the arch shaped midportion for

11. The foot keel according to claim 1, wherein the anterior end of said anterior weight bearing area is shaped in an upwardly curved arc to simulate the human toes being dorsiflexed in the heel rise toe off position of the late stance phase of gait.

12. The foot keel according to claim 1, wherein the posterior end of the posterior weight bearing area is shaped in an upwardly curved arc that reacts to ground reaction forces during heel strike by compressing for shock absorption.

13. The foot keel according to claim 1, wherein the anterior of the posterior weight bearing area includes an expansion joint hole extending through said foot keel between dorsal and plantar surfaces thereof with an expansion joint extending posteriorly from said expansion joint hole to the posterior edge of the foot keel to form plural expansion struts which create improved biplanar motion capability of the posterior weight bearing area in a prosthetic foot in gait.

14. A prosthetic foot comprising:

a longitudinally extending foot keel including posterior and anterior plantar surface weight bearing areas and a non-weight bearing arch shaped midportion extending between the weight bearing areas,

wherein the midportion is formed with a coiled spring which is compressed to absorb and expanded to return vertical load during use of the prosthetic foot.

so as to be expandable and compressible in response to ground reaction forces therein during gait for storing and releasing energy to improve dynamic response of the prosthetic foot in gait.

20. The prosthetic foot according to claim 14, wherein the posterior end of the arch shaped midportion is coiled downwardly and anteriorly to form the coiled spring.

21. The prosthetic foot according to claim 14, wherein the posterior plantar weight bearing area of the foot keel is connected to the arch shaped midportion by way of the spring.

22. The prosthetic foot according to claim 14, wherein the arch shaped midportion extends continuiously to the anterior plantar surface weight bearing area of the foot keel.

23. The prosthetic foot according to claim 14, further comprising a coupling element mounted on a dorsal surface of the posterior end of the arch shaped midportion for connecting the foot to a supporting structure attached to a leg stump of a person.

24. The prosthetic foot according to claim 14, wherein each of the posterior and anterior plantar surface weight bearing areas of the foot keel are upward concavely curved.

25. A method of absorbing and returning vertical load in a prosthetic foot during varied activities, wherein the prosthetic foot has a foot keel with posterior and anterior plantar surface weight bearing areas and a non-weight bearing arch shaped midportion extending between the weight bearing areas, the midportion at its posterior end being formed into a coiled spring, the method including:

elastically loading the arch shaped midportion by expansion and the coiled spring of the midportion by compression in response to vertically directed forces on the prosthetic foot, and

returning energy stored by the arch shaped midportion and the compressed coiled spring of the midportion upon lowering the vertically directed forces on the prosthetic foot.

26. The method according to claim 25, wherein each of said posterior and anterior plantar surface weight bearing areas of the foot keel are upward concavely curved, and wherein the method further comprises absorbing and returning vertical load upon heel-toe ground contact of the prosthetic foot in gait by the respective compression and expansion of the curvatures of the weight-bearing areas of the foot keel.

ABSTRACT

A prosthetic foot (64) incorporates a foot keel (65) and a calf shank (73) connected to the foot keel to form an ankle joint area (74) of the prosthetic foot. The foot keel has forefoot and hindfoot portions (67, 66) and a relatively long midfoot portion (68) extending between and upwardly arched from the forefoot and midfoot portions. The calf shank includes a downward convexly curved lower end which is attached at a portion thereof to the keel midfoot portion by way of an adjustable fastener arrangement (75). The adjustable fastener arrangement permits adjustment of the alignment of the calf shank and the foot keel with respect to one another in the longitudinal direction of the foot keel for tuning the performance of the prosthetic foot. The upwardly arched midportion of the foot keel, in addition to absorbing energy from vertical loading by expansion, can be formed with a coiled spring (69) which is compressed to absorb and expanded to return vertical load during use of the prosthetic in wide range of activities from walking to running and jumping.

FIG. 30

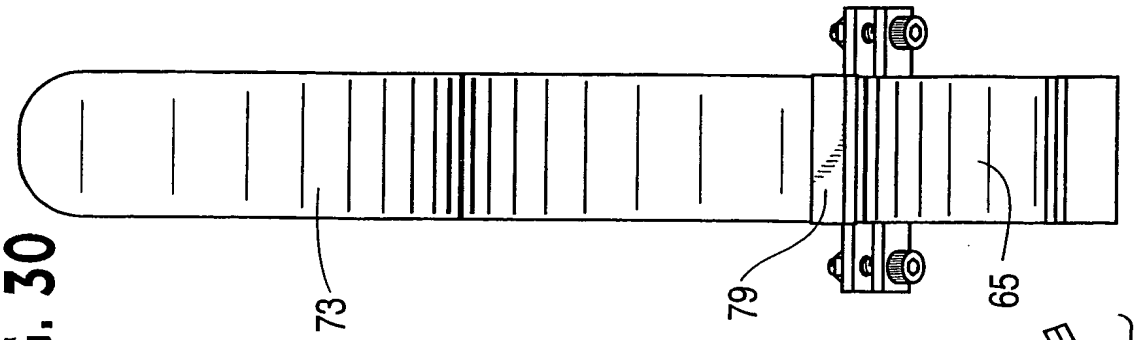

FIG. 29

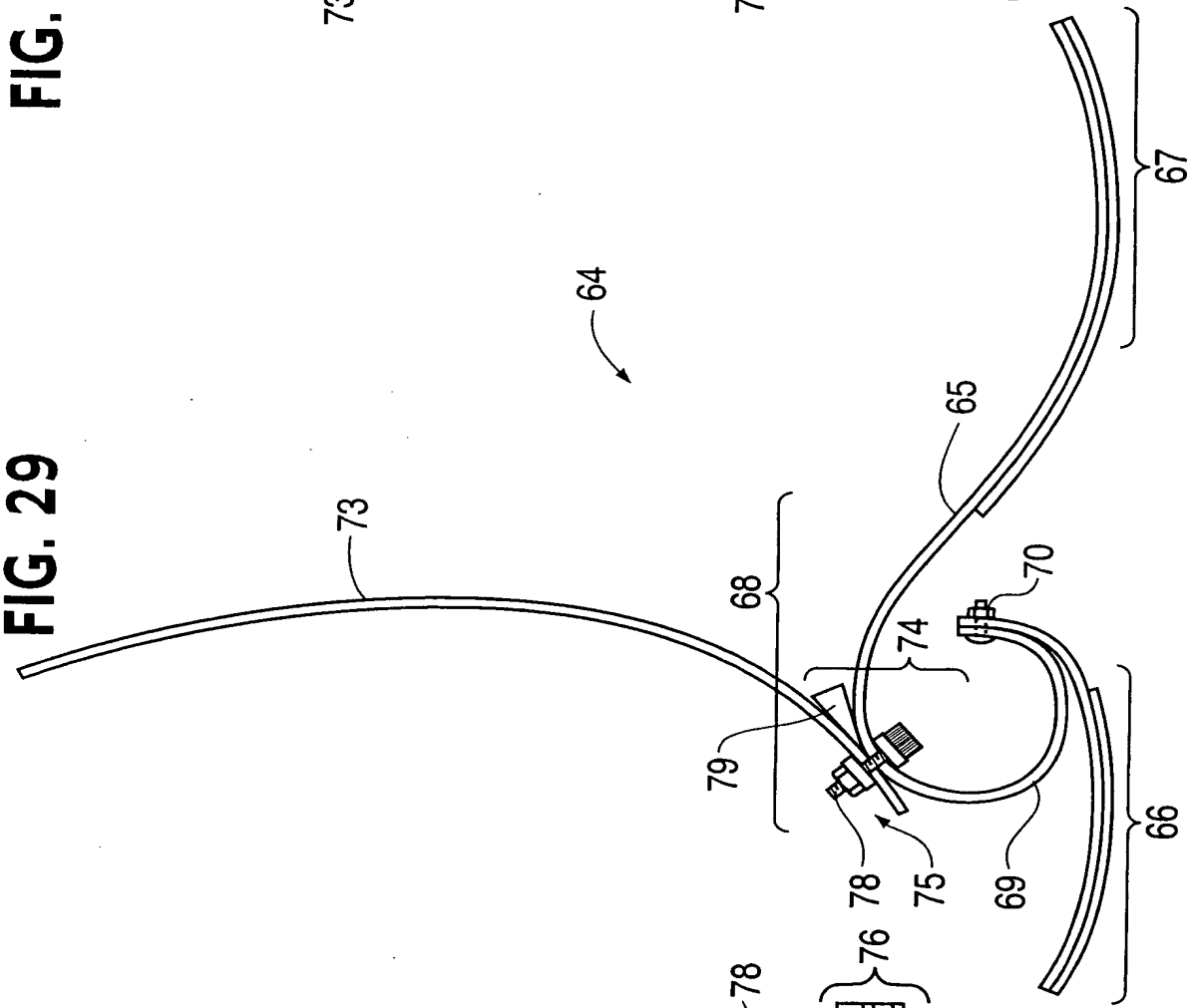

FIG. 28

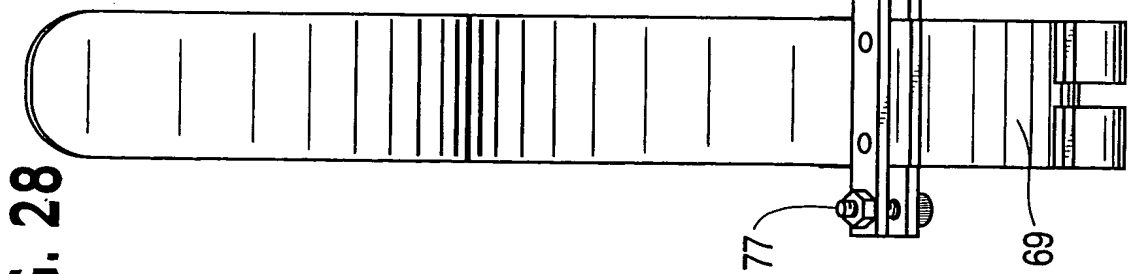

FIG.31

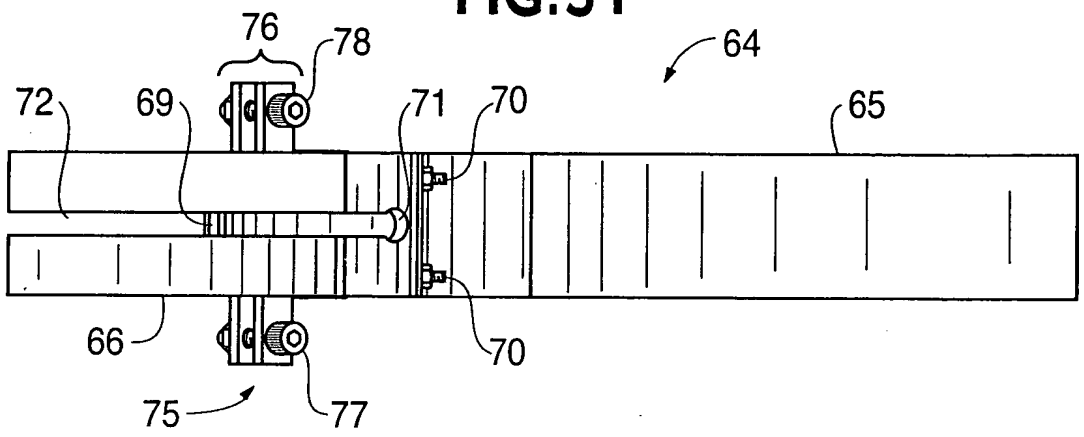

FIG. 32

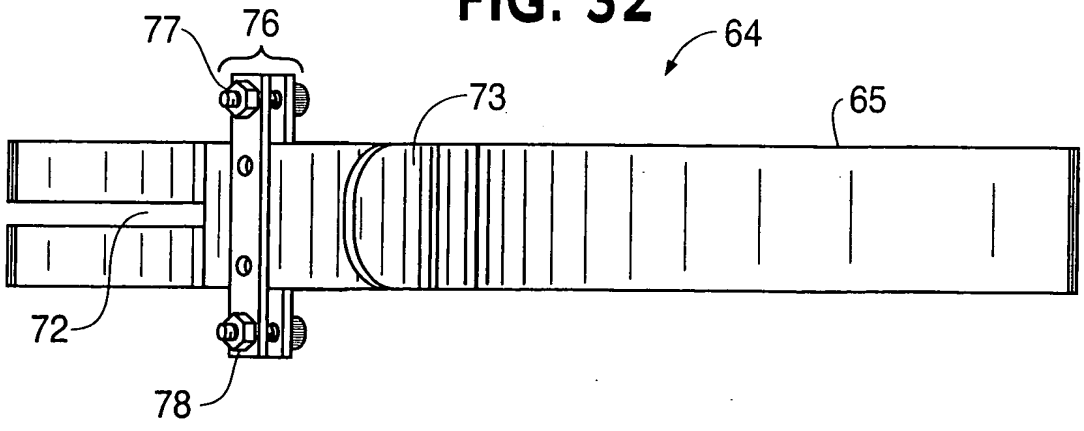

FIG. 33

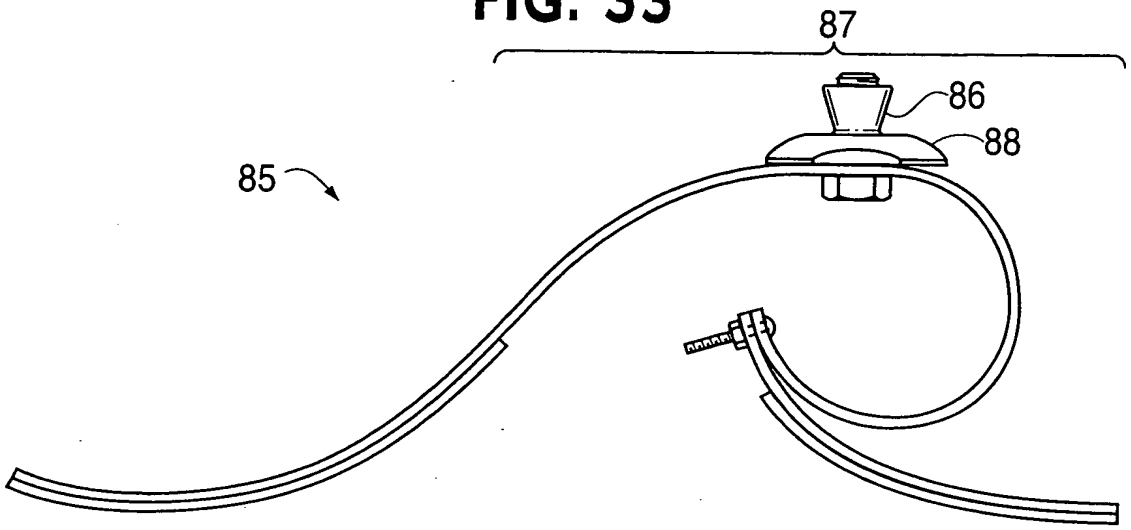

FIG. 34